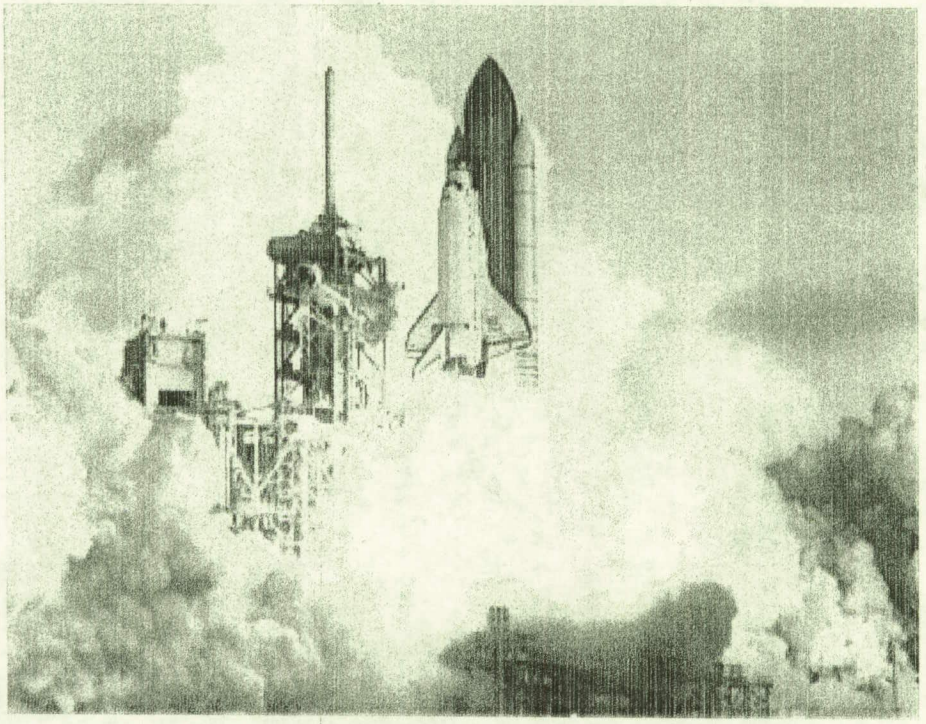
How Can the Past Influence the Future?

Industrial and Human Engineering for Spacecraft Design, Maintainability, and Operational Support

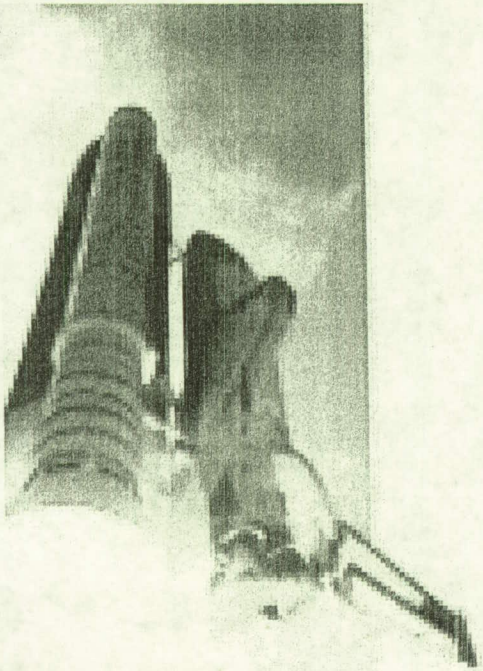


Jeffrey R. Ewald

May 6, 2005

USA
United Space Alliance

Agenda



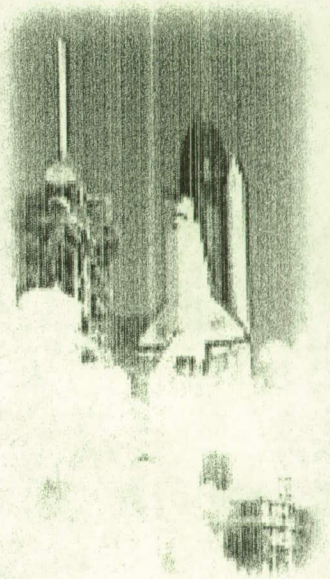
- Introduction
- Shuttle Processing History
- Role of Industrial and Human Engineering (I & HE)
- Lessons Learned: Workspace Opportunities/ Enhancements
- I&HE Techniques and Tools
- Vision for Future
- Summary and Questions

Introduction/Background

- Manager, Ground Systems Support Safety/I & HE, KSC
- _____years in Shuttle Program
  - Technician 19 XX-19 XX (or # years)
  - Quality 19XX-19XX
  - Lead_____19XX-19XX
- BS, Aeronautics, ERAU, 19XX
- MBA, _____, 20XX

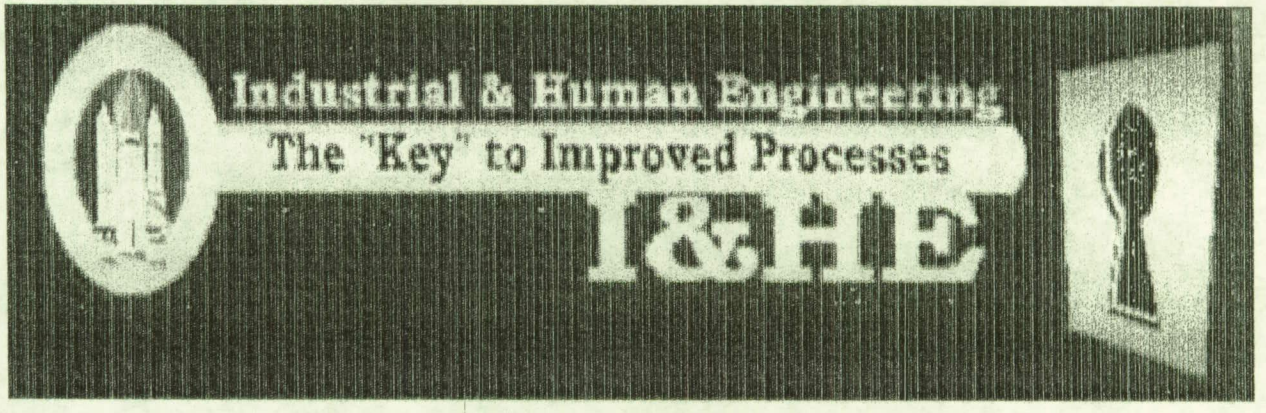
Shuttle Processing History

- Conceived as "Space Truck" to support lower Earth orbit and Station activities:
  - Designed and became operational in an era of declining budgets
  - Reliable
  - Easily Maintained
  - Rapid Turnaround
- Reality:
  - Complex, experimental vehicle requiring extensive testing & maintenance
  - IE/HE considerations not incorporated into vehicle and support design
    - Access
    - Ergonomics
    - Efficiency
  - "Can Do," Safety-Focused workforce compensated for lack of I&HE
- Extensive mods and workarounds = Increased cycle times and cost
- "Pay Now or Pay Later" points to future



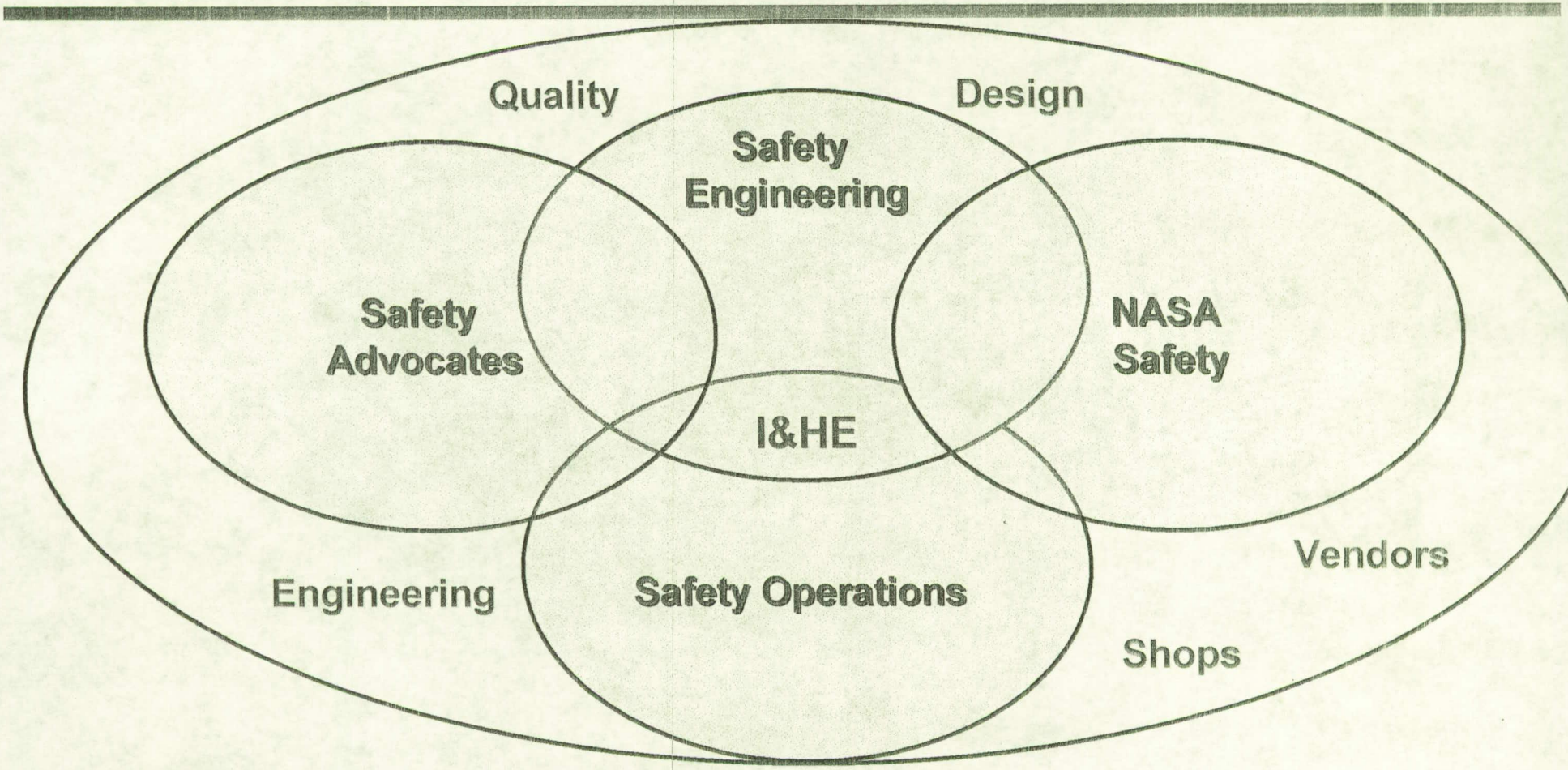
Industrial and Human Engineering (I & HE)

- 2000: Department formed in Ground Operations
- 2005: Integrated into Safety, Quality & Mission Assurance: Safety Operations
  - Orbiter
  - Launch
  - Ground Systems Support



"The dual roles of Industrial and Human Engineering (I&HE) are to reduce the potential for mishaps and to increase efficiency of Shuttle processing."

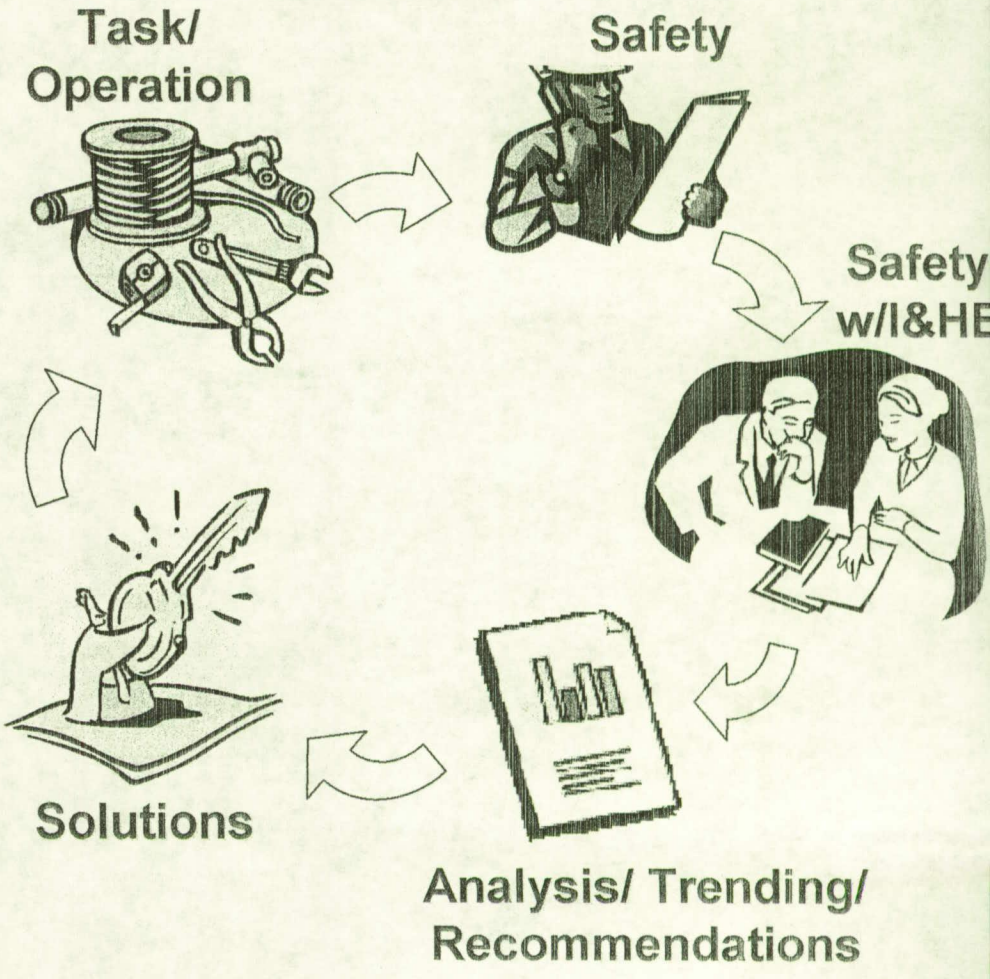
Safety Connection/Network



- Teaming among functionalities
- Daily, weekly, bi-monthly, monthly interactions
- Project/activity involvement, events, organizational insights

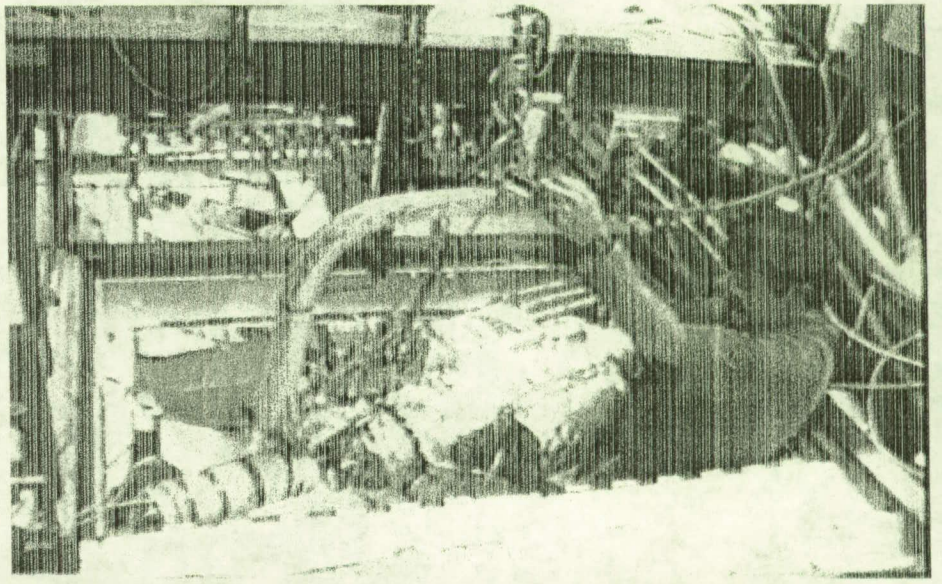
I&HE Integration into Safety Operations

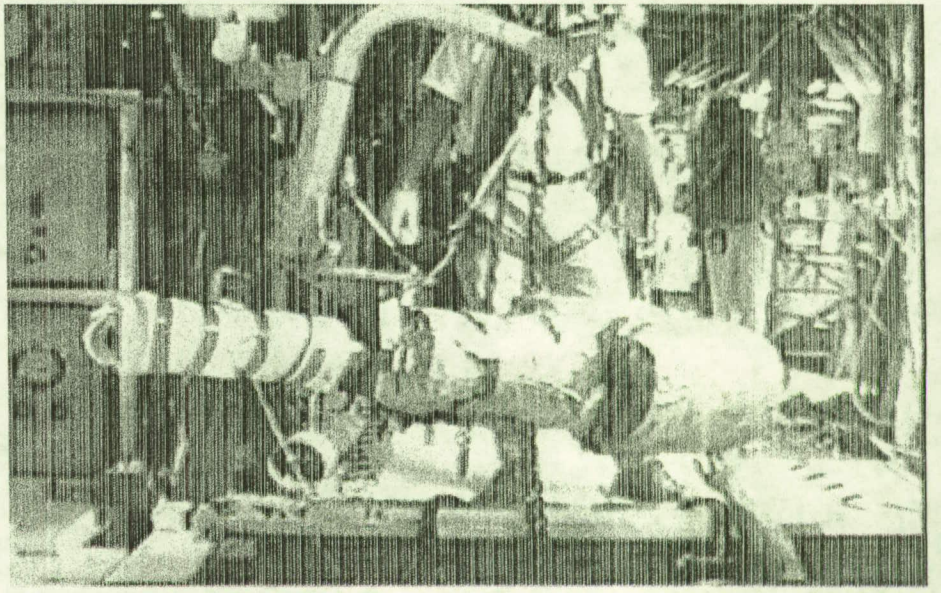
- Safety Operations
  - Walkdowns
  - Operational Involvement
  - Assure Compliance with Safety Requirements
- I&HE
  - Seek solutions to mitigate recurrences of issues
  - Walkdowns, assessments, safety analyses with multiple functionalities
  - Requirements Definition
  - End-User Input and Concurrence
  - Formal Request/Funding Submittals



Safety/Human Error Reduction Emphasis

- Safety Teams/Initiatives Support
  - Process Failure Modes & Effects Analyses
  - Risk/Safety/Usability/Task Analyses
  - Process Hazard Analysis (PHAs)
  - Shop and Engineering Requirements
  - Engineering Support Request Assessments for I&HE impacts

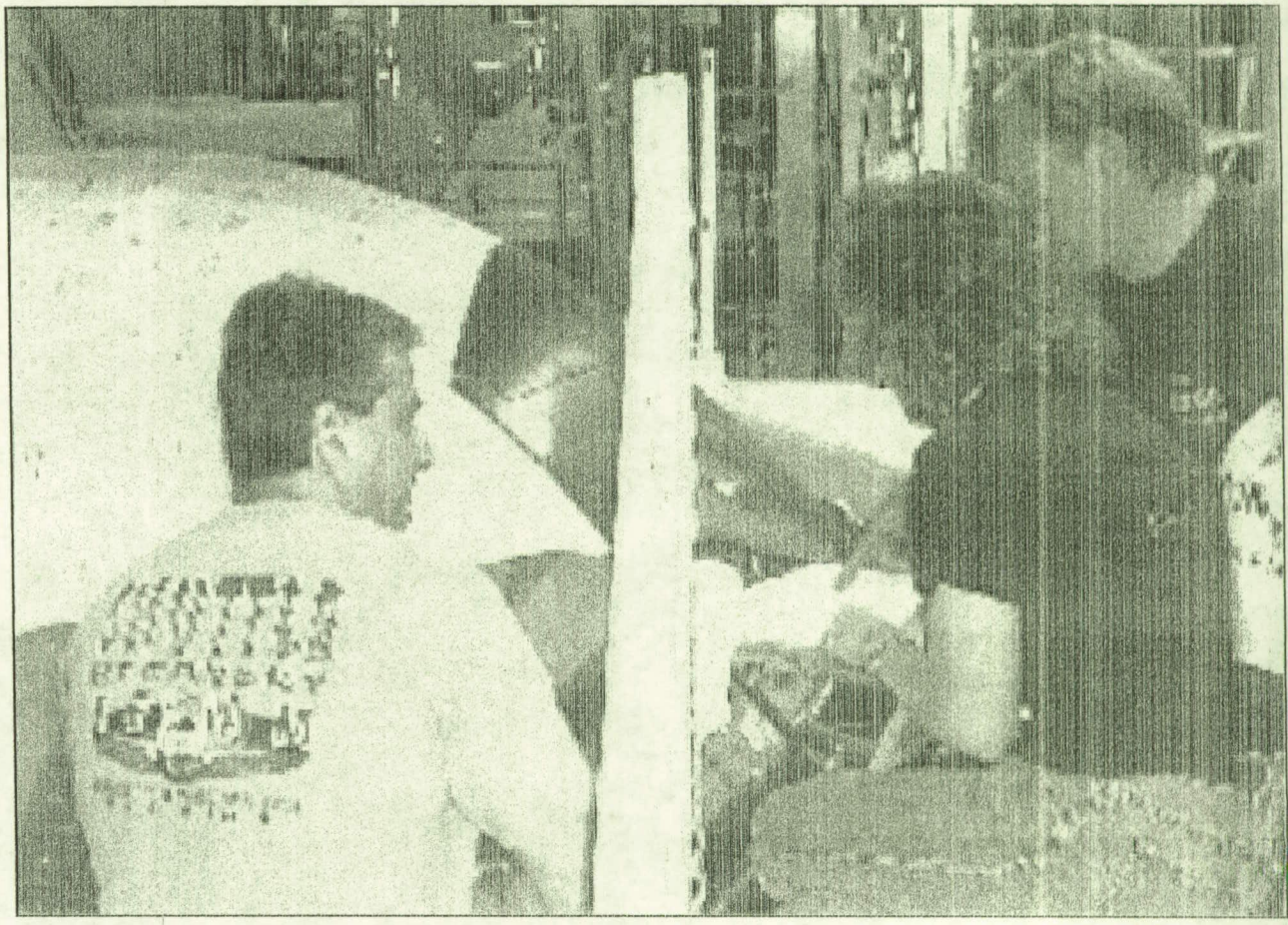




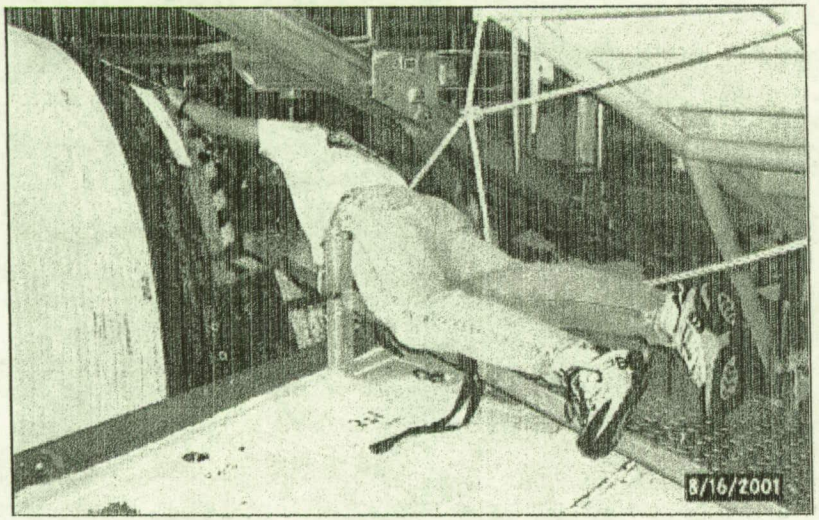
*As of 8/2004

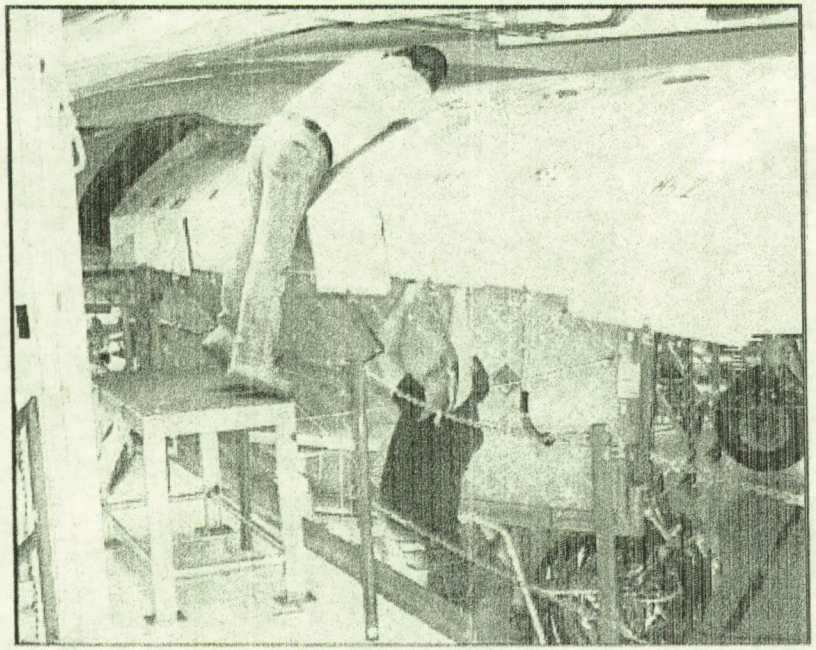
Real-Time Observations/Shop Input

- Objective Resource: Logical Decision Making vs. Subjective
- Stakeholder and End-User Involvement/ Concurrence
- Work Instruction Metrics/Feedback



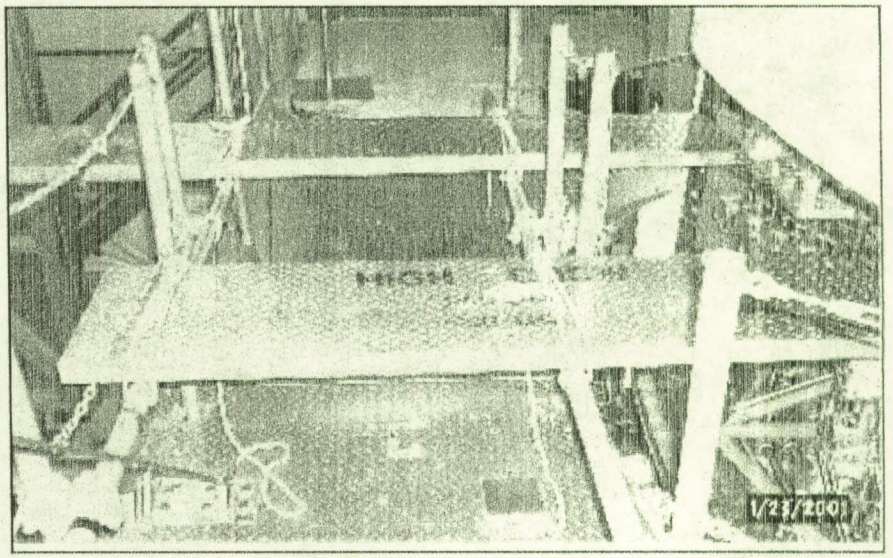
Workspace/Access Opportunities Identified





Temporary Access Opportunities Identified

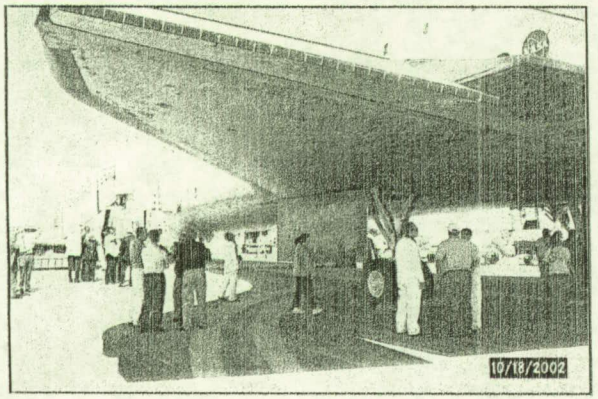
- Limited workspace
- Awkward postures
- Extended Reach
- Other



Lessons Learned: Workspace/Operational Enhancements

Opportunities Identified have included:

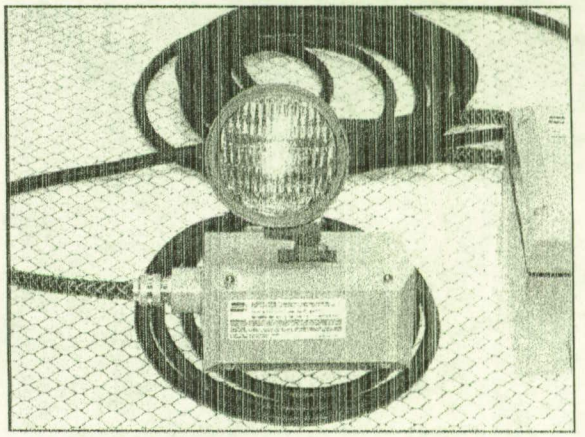
Processing



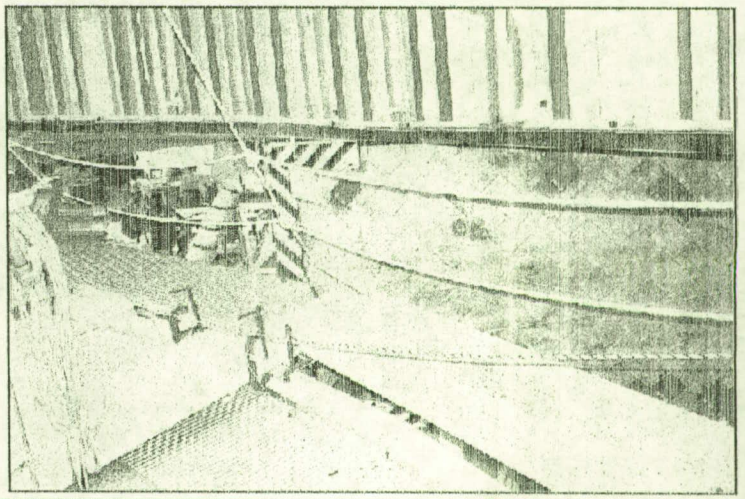
Handling

- Access
- Lifting
- Protection
- Floor Space
- Organization
- Procedures

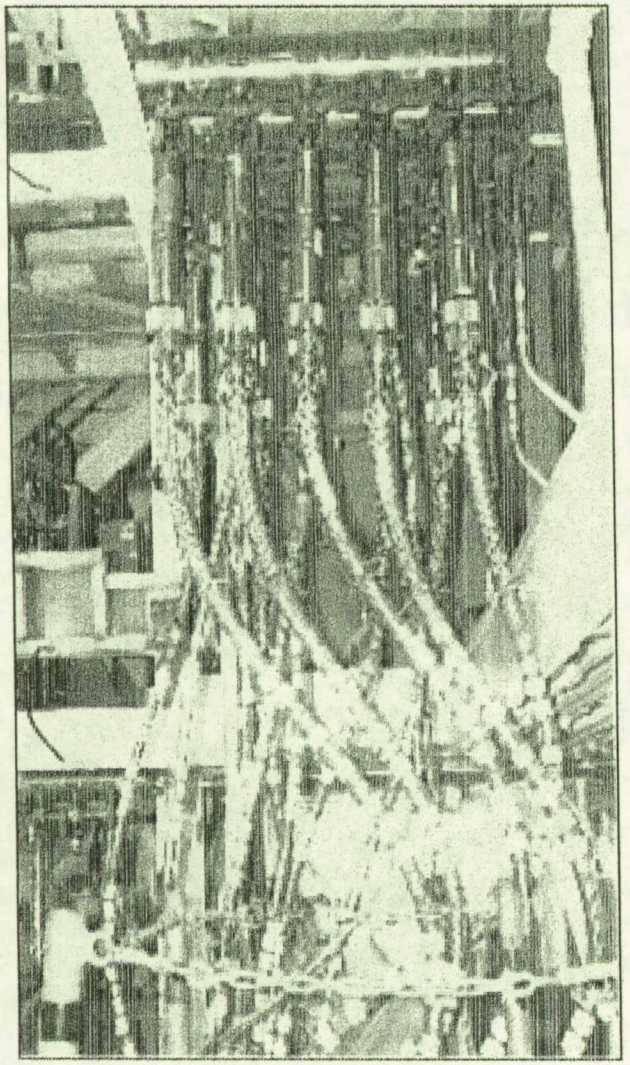
Lighting



Limited Workspace

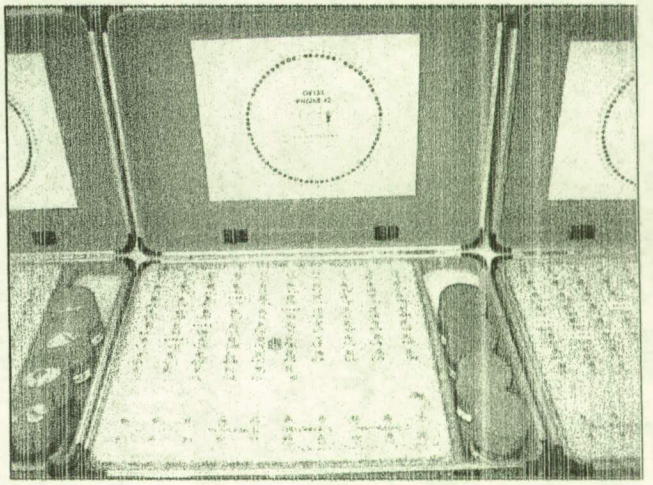


Organization/Shadowboxing

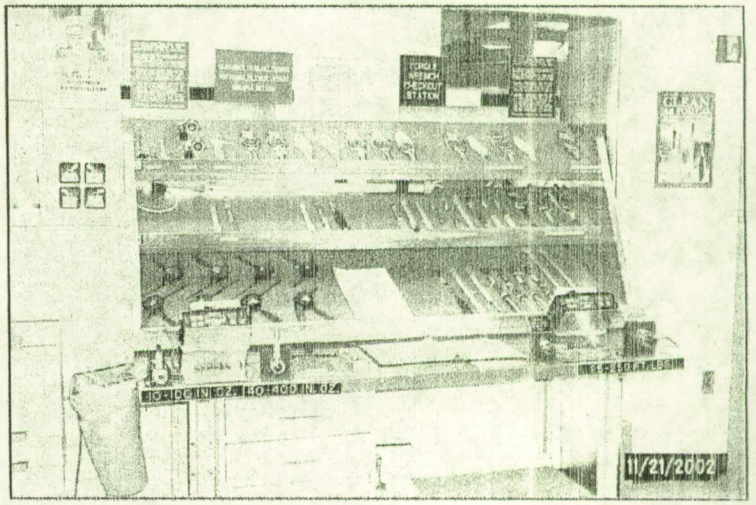


Flex Hose Lexan Organization

- Reduce Human Error
- Improve Efficiency
- Improved parts identification
- Improved parts tracking



Small Parts contained in tote box



Tool Locations Shadowboxed

*As of 8/2004

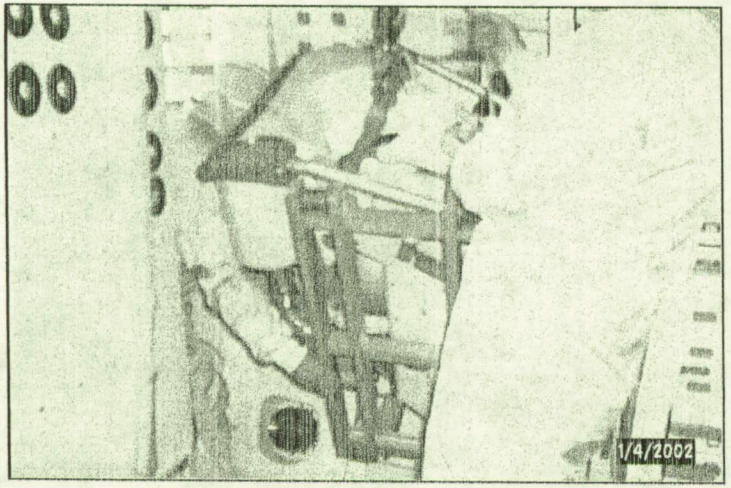
Workspace/Operational Enhancements

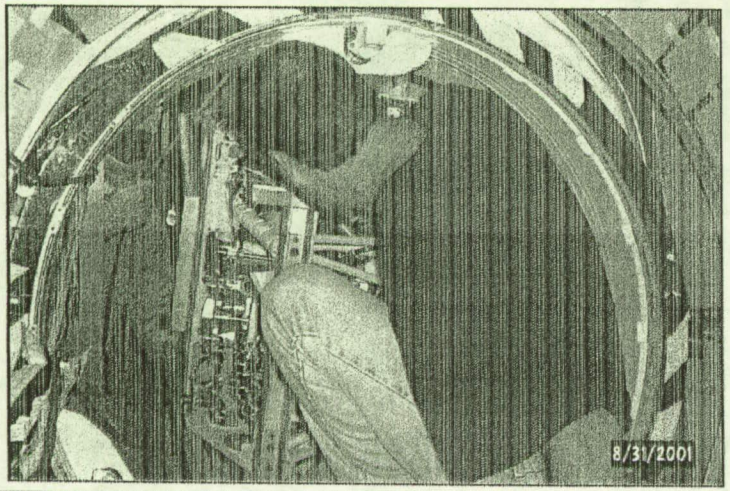
Limited Workspace:
Aft Access & Hardware Protection

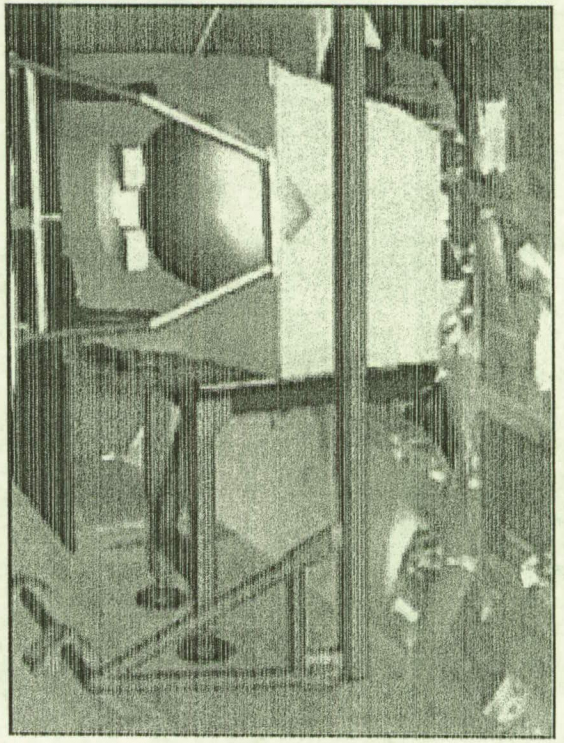
Workspace/Operational Enhancements

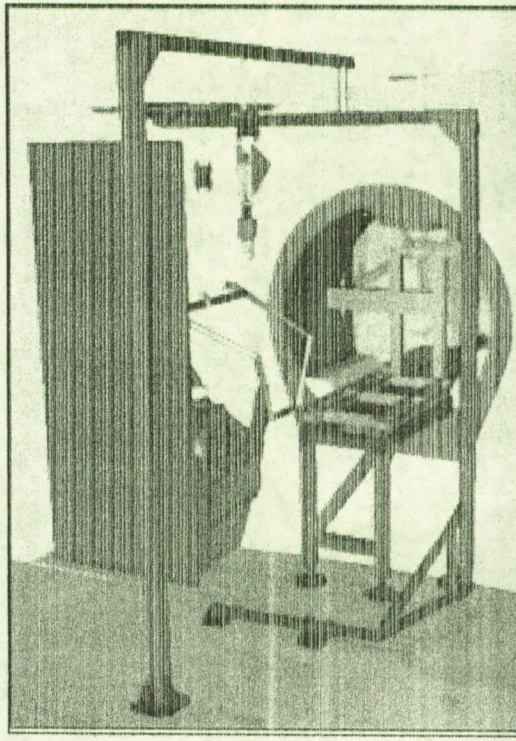
Manual Handling/Limited Workspace:

Waste Collector Subsystem Removal







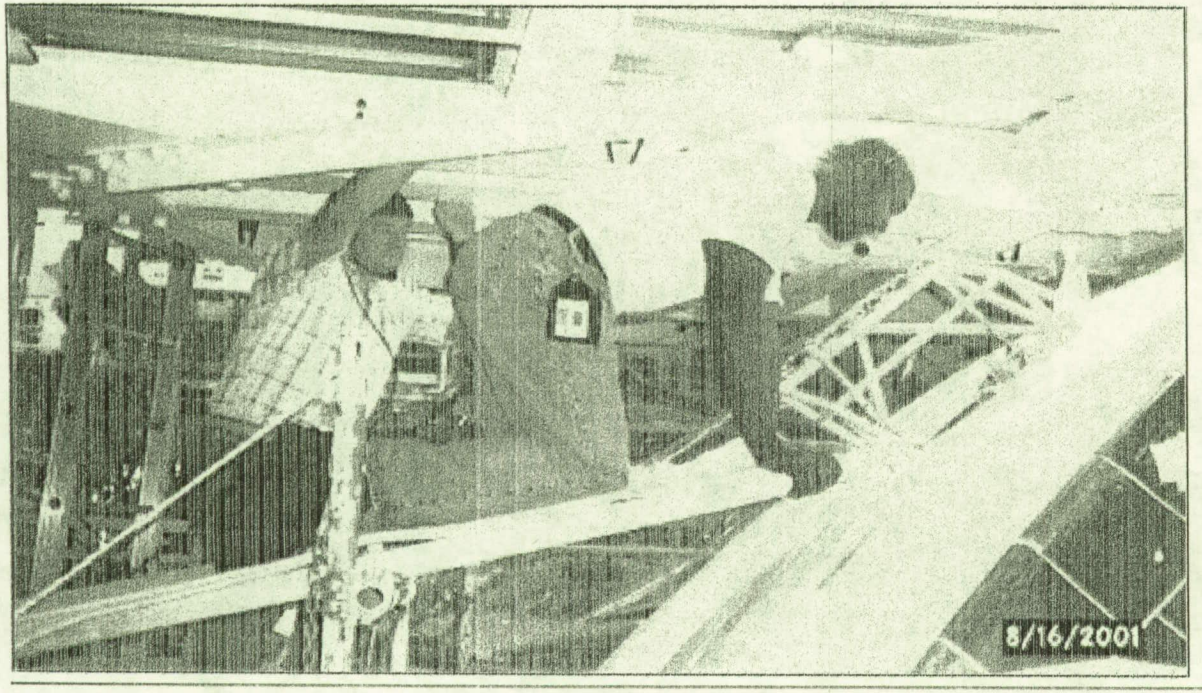


Simulated Design Concepts:
Ground Support Equipment Modifications Nearly Complete

Workspace Opportunities & Enhancements

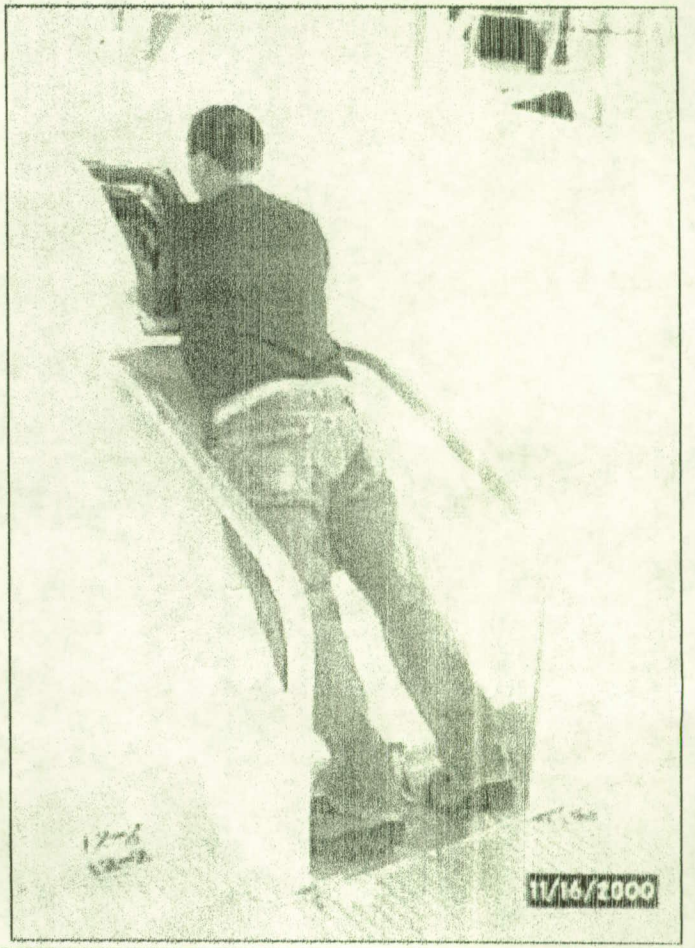
Temporary Picboard Setups:

- Contact Stress on Knees
- Limited workspace
- Restricted hands-free operations



Lean Stand

- Vertical posture
- Optimal reach

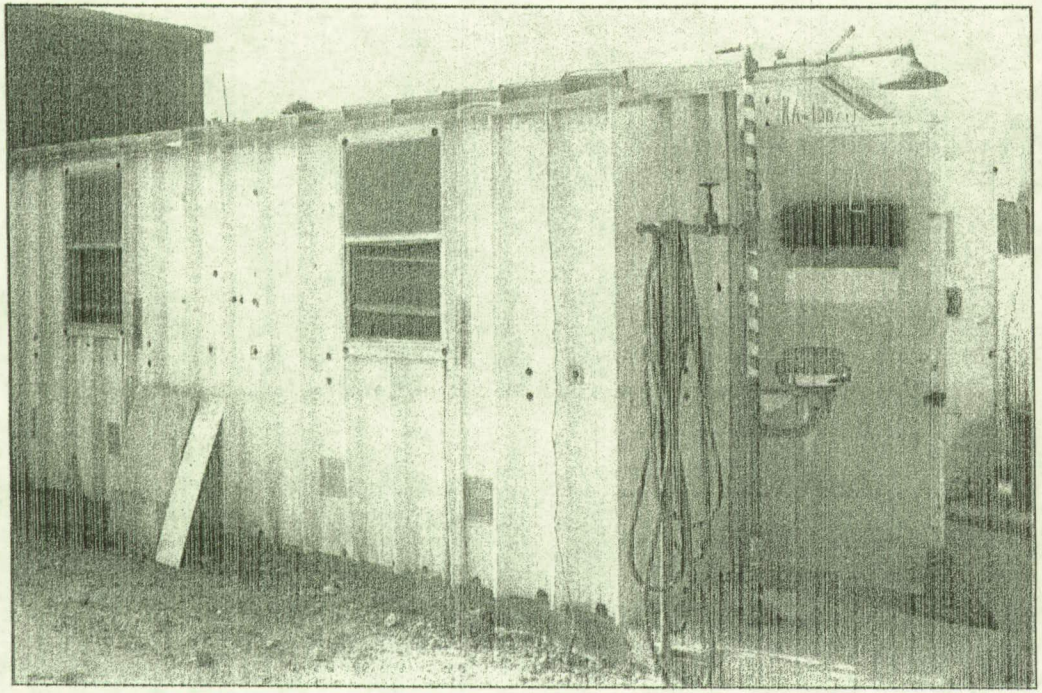


Workspace/Operational Enhancements

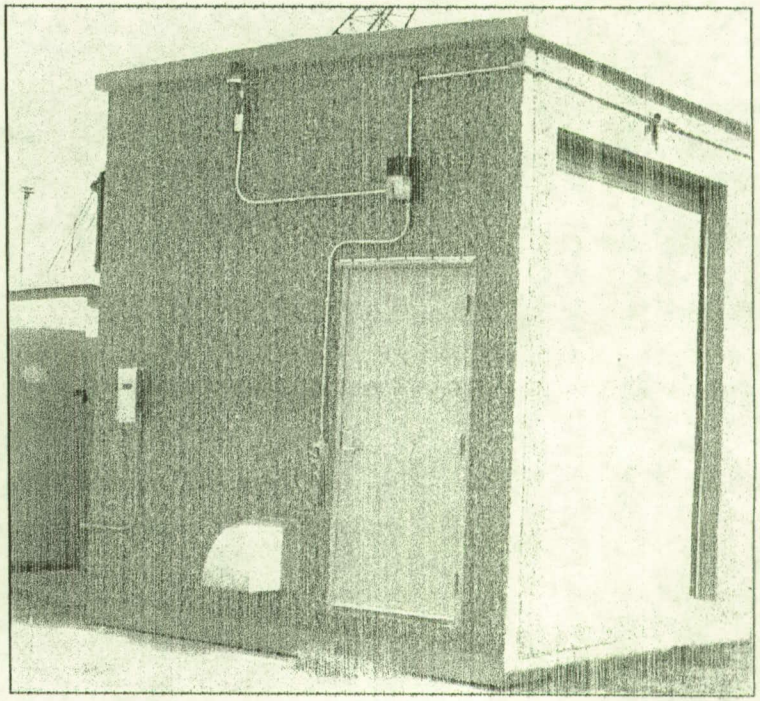
Processing Facilities:

Battery Shop

Before

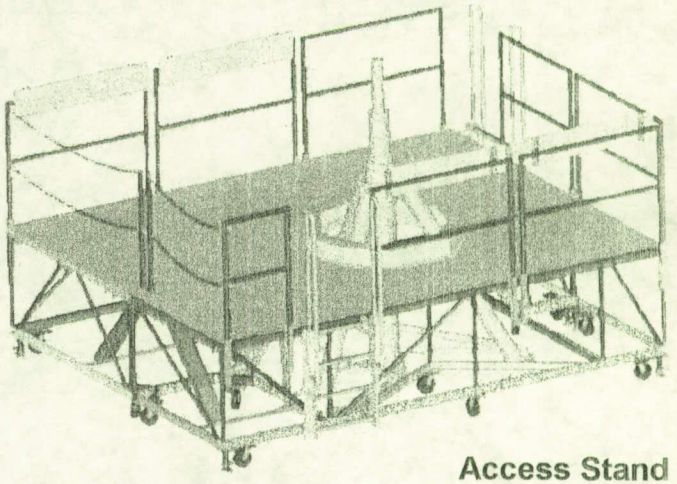


After

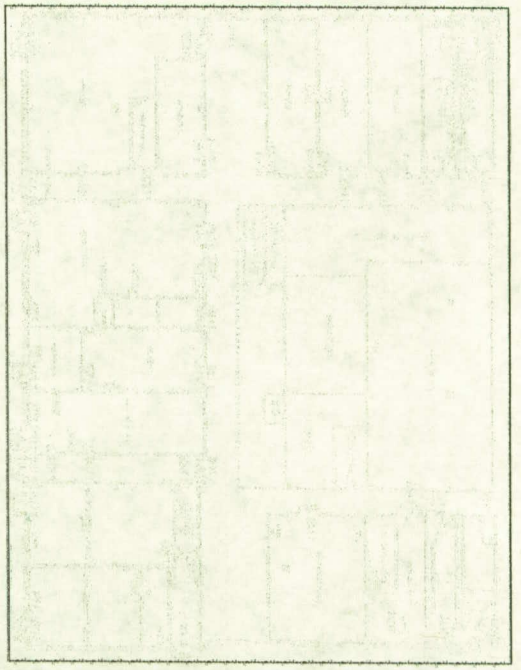


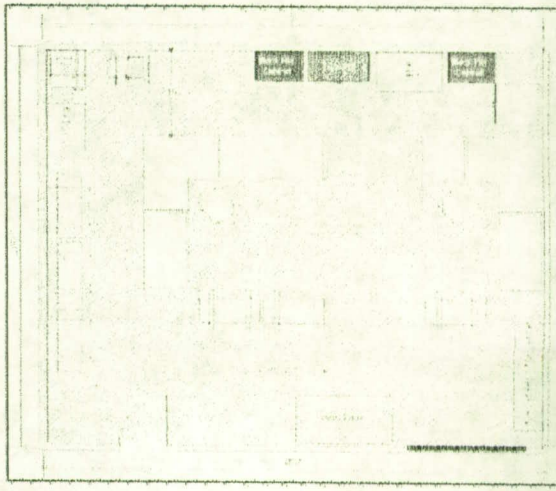
Design/Facilitation/Analysis

- Design concepts/reviews, modifications, and project management to GSE, vehicle, facilities, tools
- Facility and work flow optimization

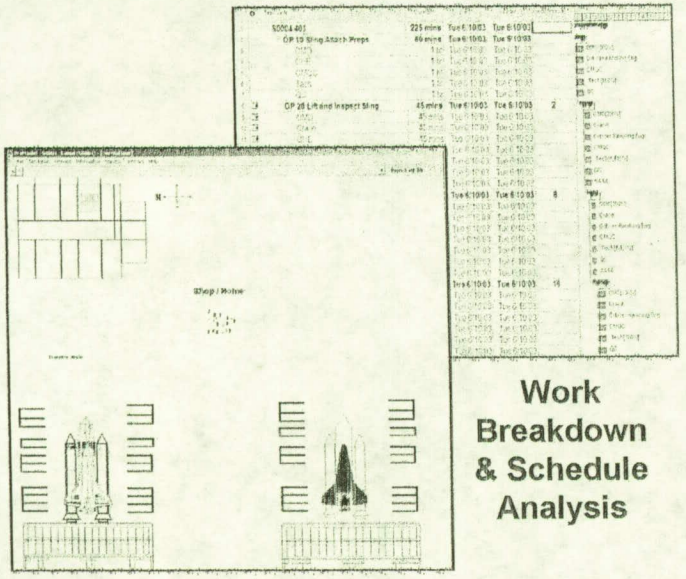


Access Stand Concept Designs

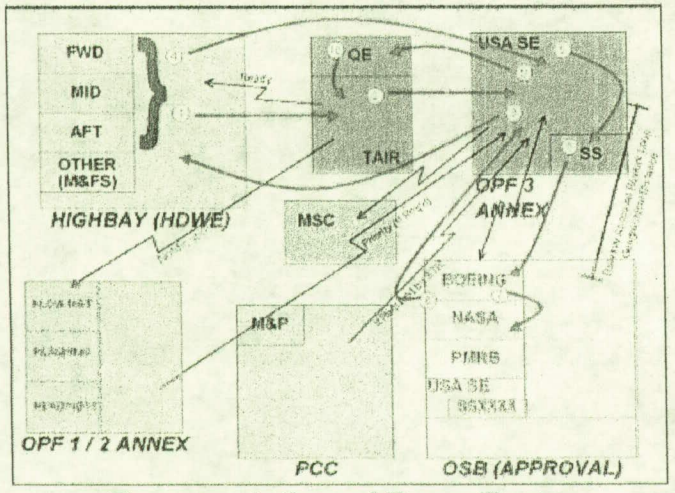




Process Analyses: Techniques/Technology



Work Breakdown & Schedule Analysis

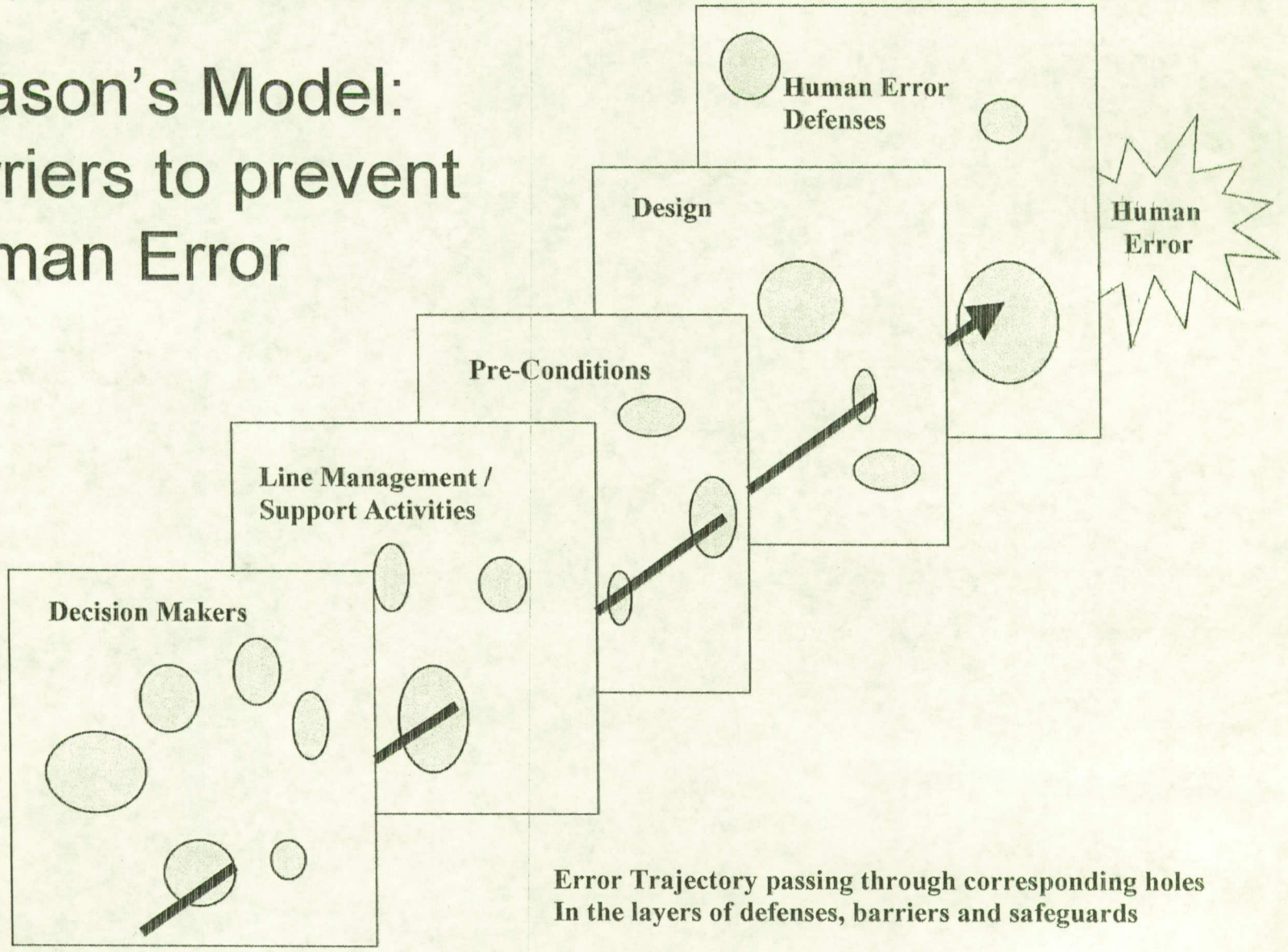


Transportation of Paper/Parts

- Process Analyses:
  - Reduce waste
  - Increase throughput/ Reduce cycle time
  - Optimize resource utilization
  - Supply Chain
- Work sampling, data collection and analysis techniques
- Discrete Event Simulation (ProModel)

Human Error Mitigation

Reason's Model: Barriers to prevent Human Error

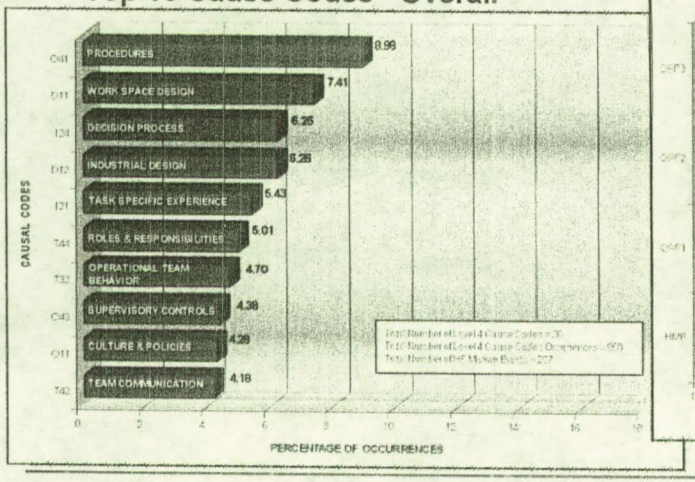


Error Trajectory passing through corresponding holes
In the layers of defenses, barriers and safeguards

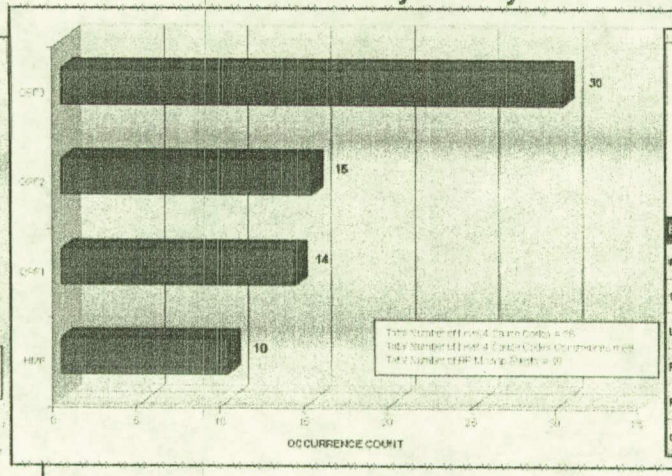
Mishap Investigation & Human Error Analysis

- Human Error Management
  - Mishap Investigations
  - Procedure Review for Compliance & Workability
- Training
  - Work Instructions, Fact Finder, Human Factors Awareness, etc.
- I&HE Human Factors Mishap Investigation Database
  - Enhanced Trending and Analysis of Systemic Issues
  - Unique in Industry

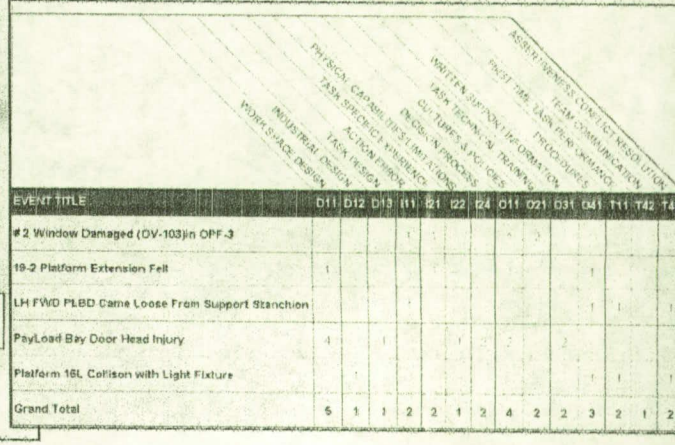
Top 10 Cause Codes - Overall



Cause Codes- By Facility



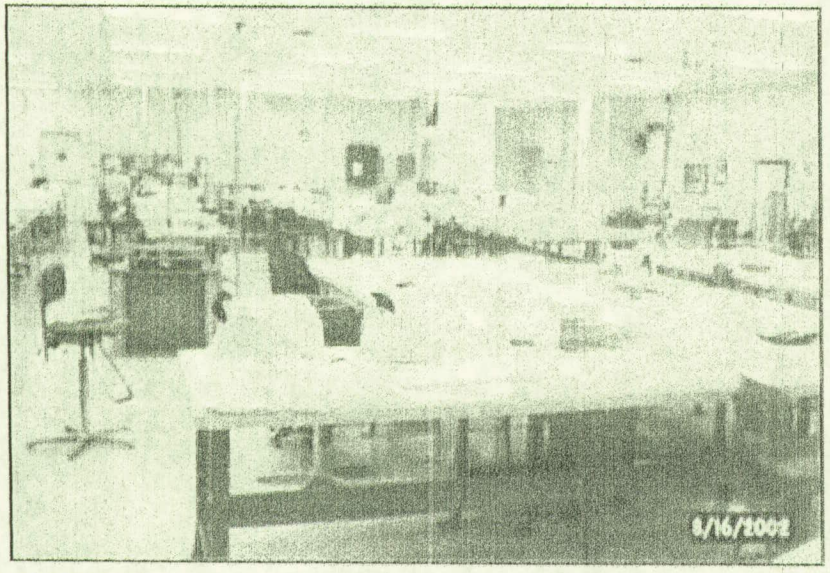
Cause Codes: Facility Location Breakdown



I&HE Overview within Spacecraft Operations

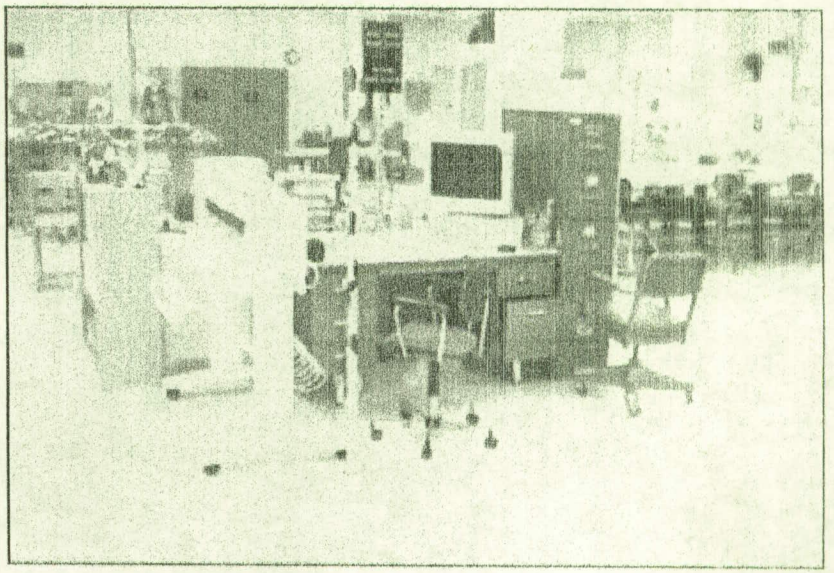
Assess processes & conditions
Identify and implement opportunities

Before



Soft
Goods
Shop

After

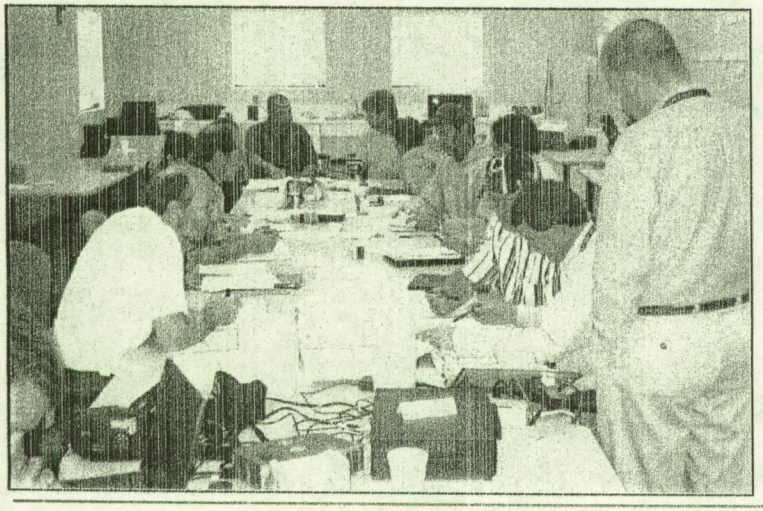


Process Improvement/Facilitation

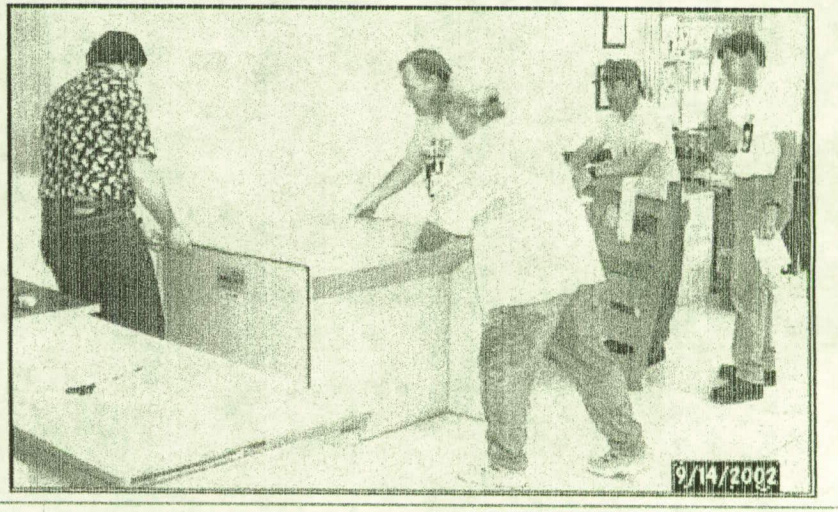
- Process Improvement Teams (PITs)/ Kaizens/5S, problem solving, process enhancement, and risk, safety, and task analysis

KSC Ground Operations
United Space Alliance
PIT CREW

Multi-Functional Teams



Implementation

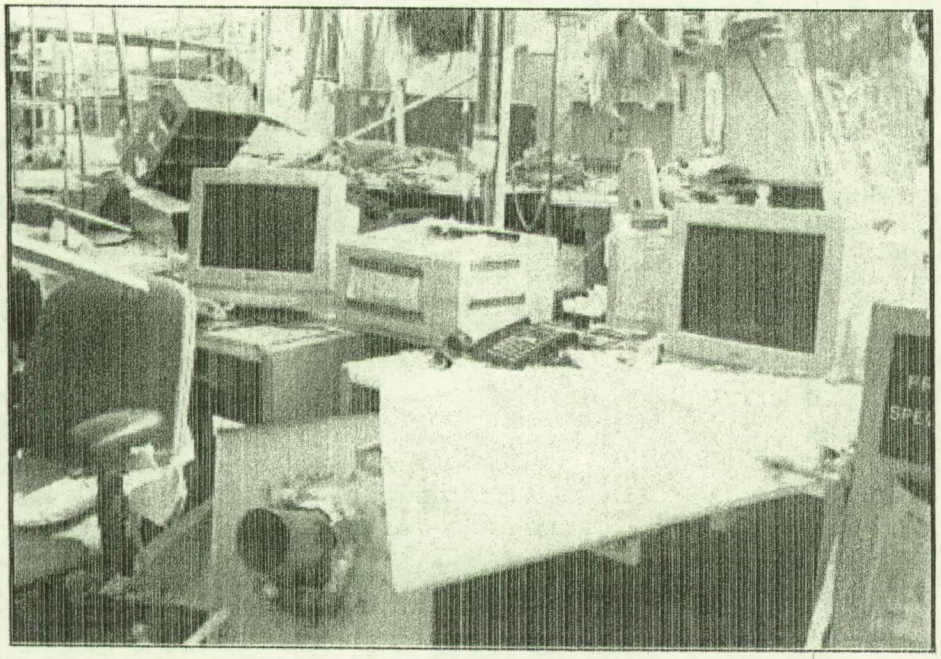


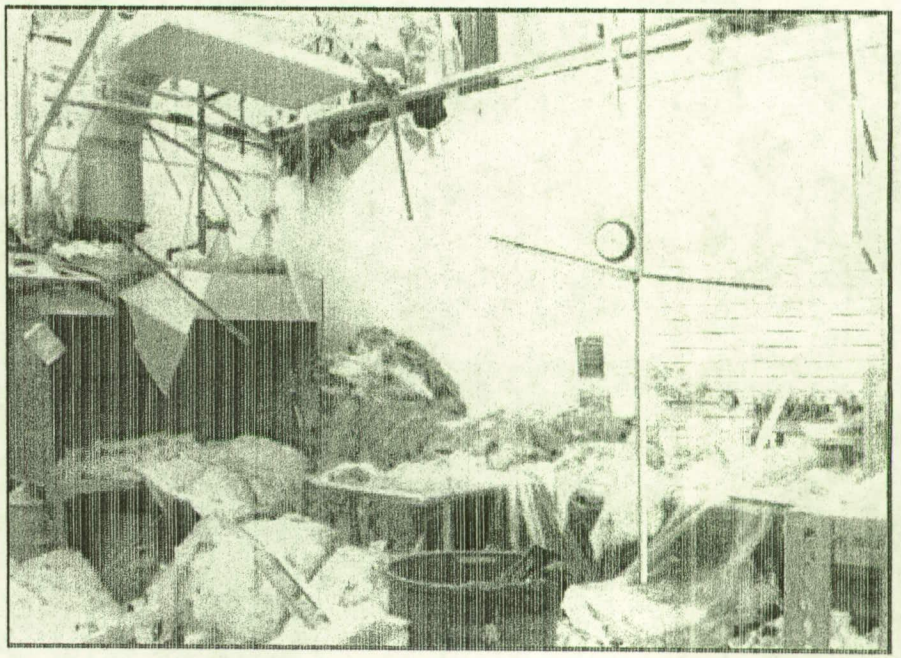
When the Unexpected Happens

- Capture Lessons Learned
- Respond and facilitate improvements

Soft Goods Shop:

Post Hurricane Frances, Summer 2004

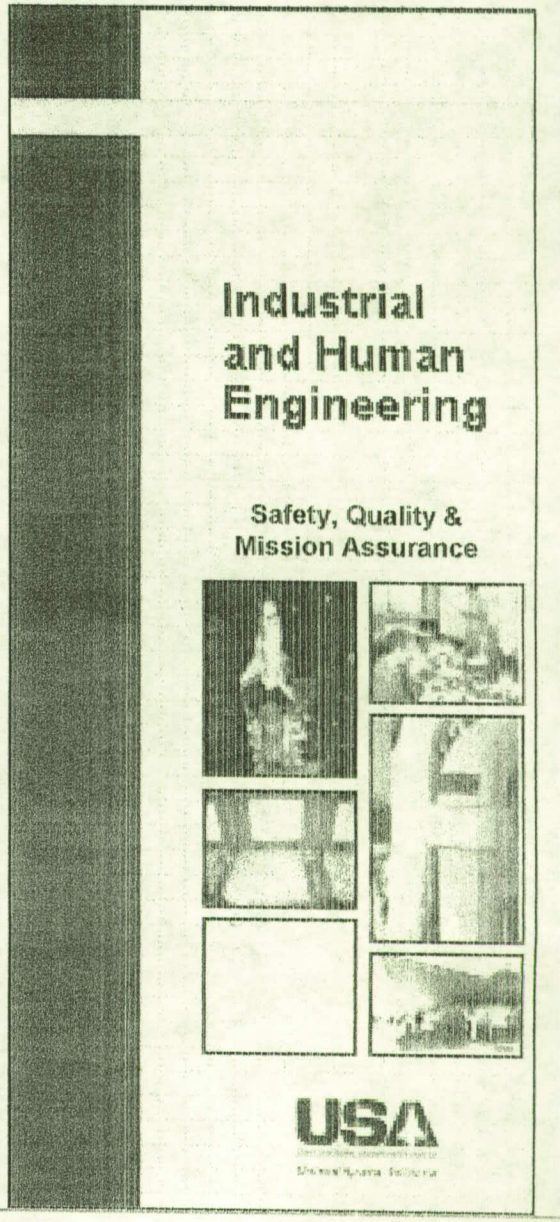




I&HE Summary: Spaceflight Processing

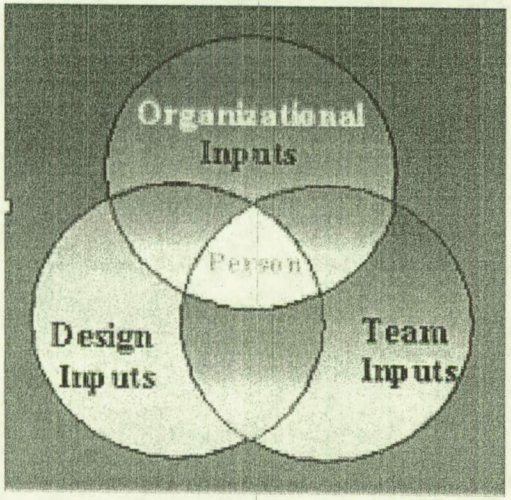
Industrial & Human Engineering

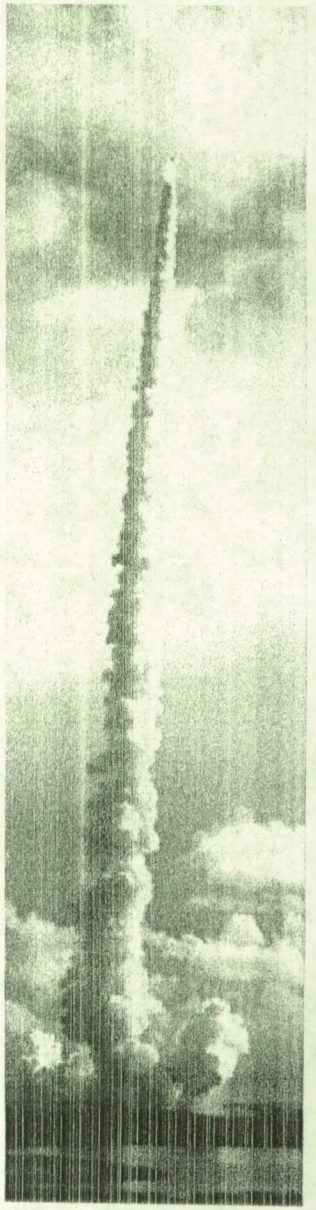
- Unique skill sets and expertise to benefit spacecraft design, support, and processing
- Ability to focus on key enhancements
- Generation of significant labor-hour reductions and material savings
- Significant additional intangible benefits supporting company and program goals
- Centrally-located valuable services to customers



Vision for Future

Investment in I&HE, incorporated at the start of spacecraft design, will ensure safety, efficiency, maintainability, and operational support and continue to create long-term benefits for the life of the system.





QUESTIONS ?

Industrial and Human Engineering